FACULTY OF SCIENCE

ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

MODULE	**COMPUTER SCIENCE 3B** CSC03B3
CAMPUS	AUCKLAND PARK CAMPUS (APK)
EXAM	NOVEMBER 2021
DATE: 2021-11-03	**SESSION:** Normal
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DURATION: 180 MINUTES	**MARKS:** 150

Please read the following instructions carefully:

1. You must complete the assessment **by yourself** within the prescribed time limits.
2. No communication concerning the assessment is permissible during the assessment session *except* with **ACSSE** staff members.
3. You are *bound* by **all** university regulations including, but not limited, to assessment, plagiarism, and ethical conduct.
4. You *may not* directly take any text or source code from any reference, including your own previous submissions. All text and source code *must* be written by **yourself** *during* the assessment.
5. You are allowed to submit either a *typed submission* or a *pen and paper submission*.
6. If you are submitting a *pen and paper submission* then:
    - Write *cleanly* and *legibly*.
    - Make use of CamScanner (or equivalent) app to create a single PDF from your written work.
7. **All answers** must be in a *single* **PDF** file. Make sure your details appear at the top of the first page of the PDF file. The name of the file must be in the following format:
   `SURNAME_INITIALS_STUDENTNUMBER_CSC3B_2021_EXAM.pdf`
8. Upload the *single* **PDF** file of your answers to both Blackboard and EVE **BEFORE** the timer expires. Failing to submit to Blackboard means you did not hand in on time and will not earn you any marks.
9. Complete the Honesty Declaration and upload it to the relevant practical on EVE. The completed **Honesty Declaration** is required for a submission to be eligible to be marked.
10. Additional time for submission is allowed for as per the posted deadlines on EVE.
11. This paper contains **9** question(s).
12. This paper consists of **7** page(s) excluding the cover page.

QUESTION 1: Operating Systems - General

(a) An operating system ***multiplexes resources*** in *time* and in *space*. **Provide** one example of a ***time multiplexed resource*** and one example of a ***space multiplexed resource***. **[04]**

(b) **Compare** and **contrast** ***microkernel*** based *operating systems* and ***monolithic kernel*** based *operating system*. You may provide a diagram to aid your comparison **[08]**

(c) **Describe** how an operating system *abstracts* the ***concept of a file***. **[03]**

Total: 15

QUESTION 2: Processes and Threads

(a) **State** if the following ***process termination*** *conditions* are voluntary or non-voluntary.

i. Error exit **[01]**

ii. Killed by another process **[01]**

(b) **Compare** ***monitors*** and ***locking variables*** as *methods of synchronisation*. **[04]**

(c) **Name** the two (2) ***types of threads***. **Discuss** performance considerations, with respect to scheduling, for each of these thread types. **[04]**

(d) Consider the following processes in a *preemtive* system (Highest priority = 0): **[05]**

Process	Priority	Burst Time (msec)
A	0	12
B	1	6
C	0	2
D	1	2

Using the ***priority scheduling with priority decrease*** algorithm with a `5 msec` quanta provide the order execution in the following format (copy and complete the table into your answer sheet):

Time Spent	...	...
Process	...	...
Priority when run	...	...

Total: 15

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QUESTION 3: Memory Management

(a) Given a fictional CPU. **Determine the 7-bit physical memory address in decimal** for the following 8-bit virtual address, given the following page table. **[06]**

Virtual address: 240.

Index	0	1	2	3	4	5	6	7
Page Frame	01	00	11	00	00	00	00	10
Present	1	0	1	1	0	0	0	1

Show all the steps from converting from decimal to binary and then from looking up the address to converting back from binary to decimal.

(b) A computer has four page frames. The time of loading, time of last access and the R and M bits for each page are shown below:

Pages	**Loaded**	**Last ref.**	**R**	**M**
A	205	246	0	0
B	337	340	1	1
C	144	352	1	0
D	239	241	0	1

Answer the following in context of page replacement algorithms.

i. Which page will Not Recently Used (NRU) replace? **[01]**

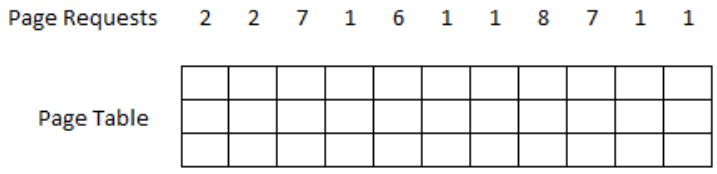
ii. Which page will First In First Out (FIFO) replace? **[01]**

iii. Which page will Least Recently Used (LRU) replace? **[01]**

iv. Which page will second chance replace? **[02]**

(c) The following diagram shows a page table with three entries. The diagram further describes a sequence of requests for pages. **Redraw** the diagram on your answer sheet and indicate how pages are paged into and out of the page table given the ***Optimal*** page replacement algorithm for each request in the sequence. **[05]**

Clearly indicate the number of page faults and where they occur.



(d) Consider a 16-bit virtual address space of 64 virtual pages.

Each page has an address space of 1024 addresses.

The physical memory consists of 32 page frames.

Answer the following question related to this virtual and physical memory arrangement.

Show the relevant calculation for each fo the answers.

i. How many bits are used in the offset for each of the virtual and page frames? **[02]**

ii. How many bits are necessary to represent the virtual page number? **[01]**

iii. How many bits are necessary to represent the physical page number? **[01]**

Total: 20

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QUESTION 4: File Systems

(a) Given the command prompt below, **answer** the following questions:

```
E:\Project\Marketing>tree \ /F
Folder PATH listing for volume KALI LIVE
Volume serial number is C212-D5B0
E:\
└───Project
    │   Index.txt
    │
    ├───Marketing
    │       poster.pub
    │       promo.mpg
    │
    └───Sales
            customers.txt
```

i. **Provide** the *absolute path* for the ***working directory***. **[02]**

ii. **Provide** the *relative path name* for the file called `customers.txt` from the ***working directory***. **[02]**

(b) Given the directory and file allocation table (FAT) below, answer the questions that follow.

File Name	Starting Block
.	10
..	14
File A	8
File B	12
File C	18

Directory

0	2
1	FREE
2	19
3	13
4	EOF
5	17
6	FREE
7	5
8	7
9	EOF
10	EOF
11	3
12	11
13	4
14	EOF
15	FREE
16	0
17	9
18	16
19	EOF
20	FREE
21	FREE

File Allocation Table

i. **Name** the block number of the current working directory. **[01]**

ii. **Name** the block number of the parent directory. **[01]**

iii. **List** the blocks that stores the content of File A. **[02]**

iv. **Draw** and i-node representation for File C. **[03]**

(c) **Name and briefly discuss** three methods that increases file system performance. **[06]**

(d) **List** three advantages of implementing a file system using linked list table in memory **[03]**

Total: 20

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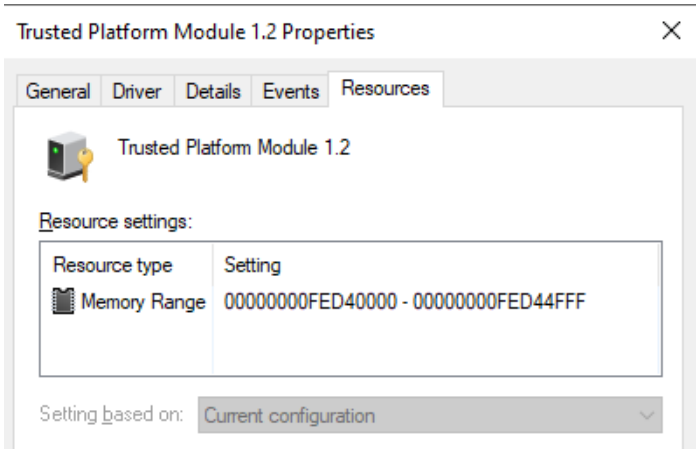
QUESTION 5: Input/Output

(a) The following picture describes the resources used by the Trusted Platform Module (TPM) built into a Dell laptop. Answer the following questions related to this resource



i. **Name** the approach the CPU can use to interface with the control registers and data buffers of the TPM. **[01]**

ii. **Briefly discuss** two advantages using this method of interfacing with the hardware. **[02]**

iii. **Briefly discuss** two disadvantages of the methods depicted in this scenario **[02]**

(b) You have been asked to write a device driver for a 3D printer. The 3D printer controller does **not** have any DMA capabilities, but include interrupt capabilities. Each 3D printed design makes use of a set of vectors. A vector is made up of two coordinates. The 3D printer reads one vector at a time, prints a layer of plastic and reads the next vector. **[05]**

Write a high-level step-by-step explanation performed by the interrupt service procedure of the device driver. (The step-by-step instructions can be written in descriptive english instead of code).

(c) Discuss device drivers. In your discussion include the following aspects **[05]**

- Where in the operating system layers the device drivers normally execute?
- Who is normally responsible for writing device drivers?
- Will the same copy of a device driver work for all operating systems?

(d) On a disk with 40 cylinders a request comes in to read cylinder 34. While the hard disk is busy servicing the request on cylinder 34, requests to the following cylinders come in: ***38,8,35,11***. **[03]**

Given these requested cylinders, if the operating system uses the ***shortest seek first***, **which** order will the cylinders be served in?

(Example if you think it will be cylinder 1 then 2 then 3 etc, write 1 2 3).

(e) **Briefly describe** what a mickey is in mouse software. **[02]**

Total: 20

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QUESTION 6: Deadlocks

(a) **Draw** a ***resource allocation graph*** for the following states **and** specify whether the system is in a deadlock: **[04]**

- Process 1 holds A
- Process 2 holds B and requests A and C
- Process 3 holds C and requests B and D

(b) Consider the following resource matrices and vectors (E - existing resources, A - available resources): **[05]**

	Printers	DVD Roms	Scanners	Tape Drives
E = (	5	7	6	5)

	Printers	DVD Roms	Scanners	Tape Drives
A = (	3	4	2	4)

Current allocation matrix

Process 1	1	1	1	1
Process 2	0	1	2	0
Process 3	1	1	1	0

C =

Request matrix

	3	2	2	3
	5	2	4	2
	1	0	3	0

R =

Use the deadlock detection algorithm to determine if the current state is in a deadlock. For each round of the algorithm give the process that ran as well as the available resource vector (A vector).

After the final round of the algorithm state whether system is **deadlocked or not** and justify your answer.

(c) In the last two weeks, two processes running on a booking server have gone into a deadlock on a daily basis. Both processes use two separate tables that are necessary for the process to complete. **[06]**

Briefly describe two techniques that you will consider as a technique to recover from the deadlock.

Total: 15

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QUESTION 7: Virtualization and MPS

(a) **Critically compare *Type-1*** against ***Type-2*** hypervisors. **[06]**

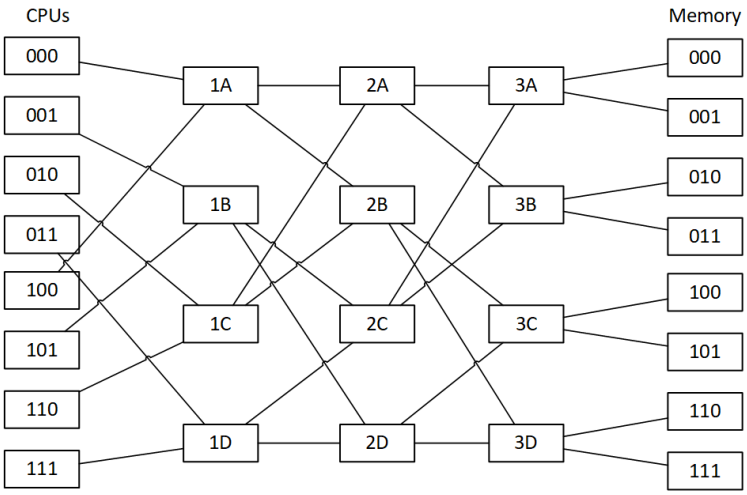
(b) You have just been employed at a cloud service provider. A colleague of yours notices that some of the servers mentions ***NUMA*** and some don't. **[05]**

Discuss *NUMA* and ***UMA*** architectures.

Include in your discussion the following aspects:

- **A brief explanation** of what NUMA and UMA is
- **Explain** why NUMA is required for some computers and why other computers do not require NUMA.
- **Describe** what characteristics you can visually see on a motherboard that may indicate whether they are using either NUMA or UMA.

(c) Given the following ***omega switching network*** answer the questions which follow:



i. **Which** switches will be accessed when CPU 000 needs to access Memory 111. **[01]**

ii. **Which** switches will be accessed when CPU 011 needs to access Memory 101. **[01]**

iii. Can the request in (i) and (ii) be simultaneously processed? Justify your answer. **[02]**

Total: 15

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QUESTION 8: 80x86 Theory

(a) **Discuss** the concept of a ***stack frame***. Your discussion must include how the stack frame is *created/destroyed* and the *use* of the stack frame. **[05]**

(b) **Draw** the stack as it will exist after the following function in the **C** programming language is called (after the stack frame is set up). The function contains local variables. **[05]**

```
1  int flex(int* values, int length)
2  {
3    int fitness = 77;
4    int bait = 2;
5  }
```

(c) **Show** the conversion of -51.6875_{10} into ***IEEE Single-Precision Representation***. Show *all the steps of your calculation* and show the final result as a *hexadecimal number*. **[05]**

Total: 15

QUESTION 9: 80x86 Cold code

Write an 80x86 assembly program that contains the following function:

```
1  .386
2  .MODEL flat
3  .STACK 4096
4  ExitProcess PROTO NEAR32 stdcall, dwExitCode : DWORD
5  .DATA
6    ; code omitted
7  .CODE
8    ; plif function code here
9  _start:
10   ; code omitted
11 PUBLIC start
12 END
```

A iterative ***plif*** function that takes the following parameters:

arrRef array address
size array length

The function will logical left shift each element in the array by 3. The function operates iteratively.

Note: The function must make use of iteration. (If you provide a solution that does not use iteration you will not be eligible for the full allocation of marks)

Total: 15

~~ THE END ~~